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A CONTROLLED FORAGING TRIP IN A COMMUNAL FOREST OF SOUTHEASTERN CAMEROON

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ABSTRACT Since 1995, we have been researching the "Wild Yam Question," that is, whether or not human beings could live without agricultural products in tropical rainforests. We conducted surveys of the distribution and reserves of yam and yam-like plants and observational surveys of 3 controlled foraging trips, during which the cooperators of the Baka hunter-gatherers could use no agricultural products, in the Ndongo area and showed the possibility human beings be able to live without agricultural products and the high reliability of yam tubers to a foraging life in the tropical rainforest of southeastern Cameroon. But there still remain some issues to be examined. Our 2 controlled foraging trips were done in a forest area which local people rarely visited and was likely to be rich in wild food resources, and the third trip was done in a forest area which they often entered to set snares and was likely to be poor in wild food resources. How does the foraging life style differ between these 2 types of forest? Furthermore, in the previous 2 controlled foraging trips the Baka cooperators used wire-snares, but did not use them on the latest trip as such durable and labor-saving wire-snares would not have been available to Stone Age hunter-gatherers. What difference does the presence or absence of wire-snares make to the foraging life style in tropical rainforests? Based on this survey of a controlled foraging trip in a communal forest which local people communally managed and exploited, we demonstrated that (1) supplying a comparable amount of food to that in remote forests rich in wild food resources, yam tubers remained a staple food for forest foragers even in a communal forest, (2) the present Baka could obtain few game animals without the use of wire snares in the communal forest, (3) game animals, like yam tubers, are a critical food for the foraging lifestyle in southeastern Cameroon forests as their scarcity has a notable impact not only on the hunter-gatherers nutritional intake but also on their emotional state.

Key Words: Controlled foraging trip; Baka Pygmy; Foraging lifestyle; African tropical rainforest; Communal forest.

INTRODUCTION

In the late 1980s, the hypothesis that it is impossible for human beings to live without agricultural products in a tropical rainforest, so called the "Wild Yam Question," was offered (Hart & Hart, 1986; Headland, 1987; Bailey et al., 1989; Bailey & Headland, 1991; Headland & Bailey, 1991). The main reason was that tropical rainforests were not rich in food resources, especially starchy food. Many anthropologists (Bahuchet et al., 1991; Brosius, 1991; Dwyer & Minnegal, 1991; Endicott & Bellwood, 1991; Stearman, 1991) refuted this hypothesis based on their own field works in various tropical forests. As a result, the arguments competed with one another for credence. Then in the late 1990s, Mercader's research team excavated one site after another in the African tropical rainforests (Mercader et al., 2000; Mercader & Brooks, 2001; Mercader et al., 2001; Mercader, 2002; 2003; Mercder & Marti, 2003) and found there were the Later Stone Age sites in the forested areas of eastern Democratic Republic of Congo, southwestern Cameroon and Equatorial Guinea, where dense forest environments have existed for the last 10,000 years and before that open forest environments even in the Leopoldvillian cold climate period. Their work provided definitive evidence to deny the hypothesis of the Wild Yam Question. However we don't know how those forest dwellers acted and lived and what forest food resources they used.

Since 1995, we have surveyed the distribution and reserves of forest food resources, especially wild yam tubers, in the tropical rainforest of southeastern Cameroon. Our findings suggested that the forest of southeastern Cameroon could have enough wild yams and yam-like plants to sustain a foraging lifestyle in a tropical rainforest (Sato, 2001; 2006). Since 2001, we have made observational surveys of controlled foraging trips, during which no agricultural or commercial food except salt and pepper could be used, to challenge the Wild Yam Question and to reveal details of how they lived off the land. Gaining the cooperation of the Baka hunter-gatherers, we had a preliminary 10-day trip in the minor dry season of August 2001, two 20-day trips in the minor dry season of August 2003 and in the major rainy season of October 2005, and a 14-day trip in the minor rainy season of April 2010 in the forest of southeastern Cameroon. Observations of these 3 trips in 2003, 2005 and 2010 found no evidence that it was impossible for human beings to live independently of farmed agricultural products in a tropical rainforest environment (Sato et al., 2006; Sato et al., 2012). Furthermore this serial survey suggested that in the northwestern Congo Basin, rich in wild yam tubers, a foraging lifestyle was possible although at a high energy cost to secure sufficient food resources to maintain it.

However, we have not analyzed the observational data other than yam tubers in the controlled foraging trip of 2010. The trip in 2010 was conducted under more severe conditions. The survey site was set in a forest closer to populated villages, unlike the survey sites of 2003 and 2005 that were set in a remote forest where people rarely visited. Because of inhabitants' routine activities, the 2010 site was likely to be under high pressure from hunting or gathering. Moreover, in this survey we did not take wire snares to the survey site as Cameroon domestic laws forbade the use of durable and strong wire snares in zoned forested areas.

In the previous 2 surveys the wire snares brought much game catch to the cooperators.

In this paper we will focus on the controlled foraging trip in 2010 and examine the potential of southeastern Cameroon forest as a human habitat through analyzing foraging activities under severe conditions.

MATERIAL AND METHOD

Controlled Foraging Trip

In April 2010, a 14-day controlled foraging trip was conducted in the forest near the Ndongo Village (Fig. 1). Because of new zoning regulations for that forest area in Cameroon the cooperators established the survey site in a communal forest about 2 hours on foot from their settlement whereas the previous survey sites in 2003 and 2005 were in a remote forest area near a national park. In the late 1990's a forest conservation project (Jengi project) started in the southeastern forest area of Cameroon (Hattori, 2008). This project aspiring for conservation with sustainable use of forest prompted land use zoning, which divided the forest area mainly into 3 zones: National Park, General Hunting Zone, Community Hunting Zone (Hattori, 2005). In principle, all hunting activity is forbidden in national parks. In the General Hunting Zone, tour companies exclusively can hunt fair game on license from the Cameroon government. In the Community Hunting Zone, ordinarily designated around inhabited areas, inhabitants communally tame and routinely use forest resources. In this paper a communal forest means a forest

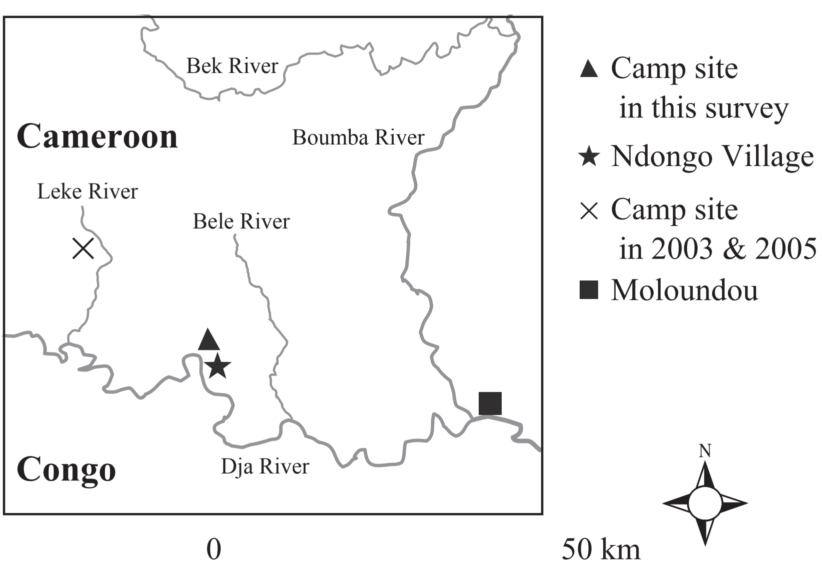

Fig. 1. Survey Area.

in the Community Hunting Zone. Therefore, forest food resources in the 2010 survey site were more likely to be scarcer relative to those in the previous survey sites. Additionally, the use of wire snares was restricted in this survey because the cooperators agreed to comply with the domestic law, which forbade the use of wire snares throughout Cameroon. We confirmed in the surveys of 2003 and 2005 that wire snares were effective and labor saving trapping gear (Sato et al., 2006; Sato et al., 2012). Concerned that this foraging trip was under much more severe conditions than previously, we decided to shorten the survey period.

The reason why we conducted this survey in April was that our surveys had not yet covered the minor rainy season, April to May, and examined whether this season was a severe season for harvesting yam tubers as Dounias (2001) and Yasuoka (2006) pointed out. The observation survey began on the morning of 14th April 2010 and ran through to the morning of 28th April 2010. After breakfast on the morning of 14th, all the cooperators depended on forest food resources (except salt and pepper) until the morning of the final day. During that time the research team members (3 men) exclusively lived off agricultural and commercial foods. In this trip the cooperators used their usual tools, such as machetes, spears, iron fittings fixed on the point of wooden digging sticks, axes, hook and line, carrying baskets, etc. (excluding wire snares), for foraging activities.

During this trip the cooperators engaged in collecting activities for wild yam tubers, wild honey, edible fungi, nuts, etc., and fishing activities. While men exclusively engaged in honey collecting and hook-and-line fishing and spear fishing, and women in dam and bail fishing, both men and women engaged in collecting yam tubers, nuts, edible fungi, and terrestrial snails.

Usually adult men had meals together, which their wives cooked, at a meeting place called *mbanjo* in the center of the campsite both in the morning and evening, whereas women and their children had meals in front of their own huts. Normal morning meals were only boiled yam tubers; the evening meal consisted of yam tubers and soup of fish or fungi with nut paste. As husbands shared the food at the *mbanjo* and wives often interchanged plates with each other, it was unlikely that a lack of food individually came about.

Survey Area and Cooperators

All the Baka cooperators lived in a sedentary small settlement near a farmers' village, Ndongo, in southeastern Cameroon (Fig. 1). The Ndongo villagers mainly consist of the Bakwele farmers while the Baka, about 300 people, are the largest ethnic group around the Ndongo Village. At present almost all of the Baka settle along a main road and keep crop fields and cacao field, as neighboring farmers do (Kitanishi, 2003). In addition, they get some money, local alcohol and food by helping local farmers. Still, they customarily enter the forest to catch animals and collect seed nuts such as wild mango seeds for 1–2 months a year, taking field crops, plantain bananas or cassava tubers. Thus the Baka people in this area maintain the knowledge and technology to live off the forest.

The Baka cooperators set the campsite on the bank of a small stream, called

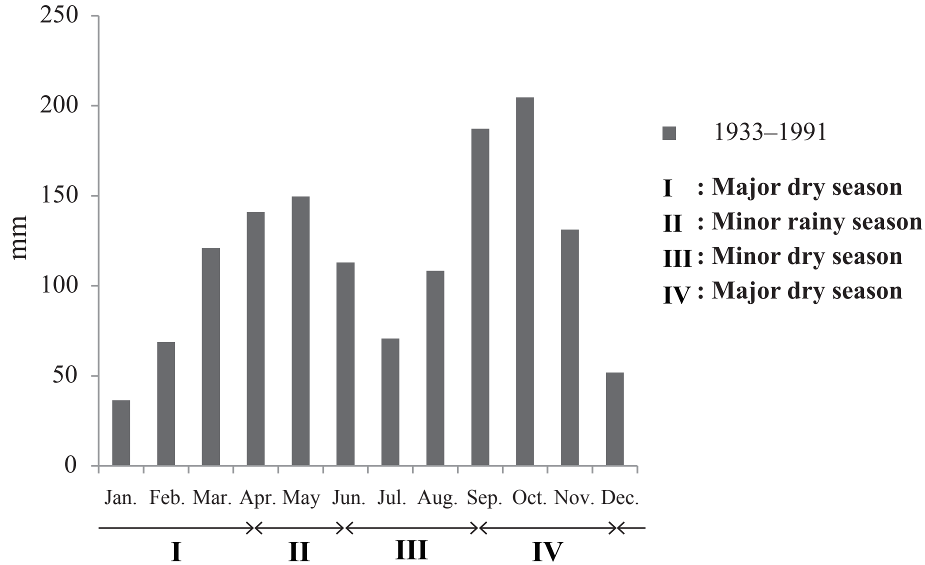

Fig. 2. Mean monthly rainfall in Moloundou. Adapted from Sigha-Nkamdjou (1993).

Table 1. Baka cooperators

Couple no. Apr. '10	Individual no.	Sex	Age estimated	Child
SRF1	SRF11	M	52–57	-
	SRF12	F	52–57	-
SRF2	SRF21	M	32–37	1 boy, 1 girl*
	SRF22	F	32–37	-
SRF3	SRF31	M	42–47	-
	SRF32	F	42–47	-
SRF4	SRF41	M	52–57	-
	SRF42	F	52–57	-
SRF5	SRF51	M	50–55	-
	SRF52	F	50–55	-
SRF6	SRF61	M	45–50	-
	SRF62	F	40–45	-
SRF7	SRF71	M	20–25	-
	SRF72	F	15–20	-
SRF8	SRF81	M	42–47	1 boy*, 1 girl
	SRF82	F	42–47	-

*: adolescent.
SRF1, SRF2, SRF3, SRF5, and SRF8 have experience partipating in one or more controlled foraging trips.

Mesimebem. The survey area around the campsite was a hilly area around 400 meters above sea level. The vegetation around the survey area was a semi-deciduous forest with an annual rainfall of less than 1600 mm (Letouzy, 1985). In the survey area there are 4 seasons: A minor rainy season, April to May, a minor dry season, June to August, a major rainy season, September to November, and a major dry season, December to March (Fig. 2). The mean monthly temperature is 25˚C all year round.

The cooperators consisted of 8 married couples, including a boy and a girl over 12 years old, and a boy and a girl under 10 years old (Table 1). A couple (SRF6) was accompanied by a dog. Since the cooperators didn't habitually count their age, we estimated their age except for the children whose ages we could identify. 5 (SRF1, SRF2, SRF3, SRF5 and SRF8) among 8 couples participated in the previous trips 1 or 2 times. The other 3 couples consisted of 1 couple (SRF6) who helped us with the distribution surveys of wild yam plants in 1995–1996, and 2 couples (SRF4 and SRF7) who were recommended by other cooperators.

Survey Method

We checked the body weight of cooperators and their children using a digital weight scale every morning (6:00–6:30) before breakfast. We timed every cooperator going out and returning to the camp every day. Coming back, all the cooperators were asked what they did in the forest. From these data we estimated the time spent in foraging activities by each cooperator. Following individually a cooperator, we also observed the direct activities of 6 couples from morning (6:00) to evening (18:00) of 1 day, although we will discuss this data elsewhere. All food brought back to the camp was identified by hearing from each cooperator and weighed using a digital kitchen scale and a spring scale. All the discarded rotten food during survey periods and the remnant food at the end of survey were also weighed. Animals were identified with the aid of Kingdon's book (1997). As for the plants, we first recorded their vernacular names and then referring to Letouzey (1976), Hamon et al. (1995), and Dumont et al. (1994), we cited their scientific names. Estimating food intake, we adopted the rate of edible portions of the 2005 survey for yam tubers, nuts, leaves, games' meat, snails and termites (Sato et al., 2012). Those for snakes, fish and honey are derived from Kitanishi (1995) and those for any others are from Standard Tables of Food Composition in Japan (MECSST, 2005). The value of energy and protein contents for yam tubers (the item number, hereafter IN: 260 and 264), nuts (IN: 446), game meat (IN: 1134 and 1148, both are African beef as there is no data on wild games.), snake (IN: 1184), fish (IN: 1263 and 1251), snails (IN: 1423), and honey (IN: 1060) are derived from African food composition tables (Leung, 1968), and that for crabs (IN: 10335) from Standard Tables of Food Composition in Japan (MECSST, 2005). As for leaves Mialoundama (1993) and Standard Tables of Food Composition in Japan (MECSST, 2005) were used for reference. From above data we estimated the total energy intake of all participants in the camp and the per capita daily energy intake (the total energy intake per consumption-day). The consumption-day was the adjusted number of participants × observation days. Participants were divided into 2 categories: Adult persons and children under 10 years old, 1 person of which was converted to 70 percent of an adult person based on estimated BMR (basal metabolic rate) from body weight by sex and age grade (FAO, 2004). A portable accelerometer (Kentz Lifecorder EX, Japan) was worn on the waist of every cooperator from morning (6:00) to evening (18:30) everyday to measure the energy expenditure for foraging activities. Since the accelerometer was not made to catch the multidimensional actions of foraging activities in the forest, however, we have not used the data here. But, we used the data from a pedometer which was built-in the accelerometer and counted the cooperator's steps walked as a method to measure the cost for foraging activities. All statistical analyses were done using statistical package JMP (version 8.0.2).

Before this trip, we explained the details of the foraging trip to all the cooperators, and asked each of them to voluntarily participate in this study and gained their consent. This survey was approved by the Ethics Review Board of Hamamatsu University School of Medicine in 2009 (No. 21–36).

RESULTS

Food Procured and Dietary Energy Intake

Food brought back to the camp during the survey period consisted of wild yam tubers (5 species), yam-like plants (1 species), mammals (1 species), reptiles (2 species), amphibian (1 vernacular name), fresh water fish (8 vernacular names), crustacean (2 vernacular names), snails (1 vernacular name), honey (3 vernacular names), nuts (3 species), leaves (1 species and 3 vernacular names) and edible fungi (5 vernacular names) (Table 2). As shown in Table 2, among these, the clear first ranking in weight was wild yam tubers occupying nearly 90 percent in the weight composition. Among the 5 species of wild yam plants, an annual *Dioscorea praehensilis* (*safa*) was the most collected yam, as in the previous 2 surveys. Although in both previous 2 surveys game's meat occupied 20–30 percent in the weight composition and placed second in weight ranking, little game's meat was procured in this survey. One of the 2 small blue duikers (*dengbe*) procured was caught by the dog and one was taken from the stomach of a big snake (*buma*).

The food intake, and dietary energy intake, and protein intake by food type are shown in the Table 3. The total energy intake was estimated at 2000.1–2184.2 kcal per consumption-day. This value was marginally lower than those in both the dry season of 2003 and the rainy season of 2005. The biggest contributor to total energy intake was yam tubers which supplied 1565.4–1733.1 kcal (84.2%). This was common among the 3 surveys. However, the contribution of each food type to total energy intake in this survey was different from those in both previous surveys, where yam tubers supplied more than 60 percent of the total energy intake, game meat 15–20 percent, and nuts around 10 percent, and the sum of

Table 2. The weight of food brought into the camp during the survey period

Food Scientific name or English name	Vernacular name	Total fresh weight (kg)
Wild yam and yam like plant		
Dioscorea praehensilis Benth.	*safa*	525.1
D. semperflorens Uline	*suma*	2.3
D. mangenotiana Miége	*ba*	31.0
D. burkilliana Miége	*keke*	16.5
D. minutiflora Engl.	*kuku*	0.8
Dioscoreophyllum cumminsii	*gbi*	0.7
Mammal		
Cephalophus. monticola (Thünberg)	*ndengbe*	2.7
Reptile		
Osteolaemus sp.	*mokakele*	4.9
Bitis gabonica gabonica	*buma*	2.8
Amphibia		
frog	*kpopo*	0.0
Fish		
electric catfish	*gbibi*	0.2
catfish	*kannya*	0.3
catfish	*ngolo*	3.4
characin	*denge*	13.7
characin	*jilelo*	0.0
cichlid	*toko*	0.3
?	*mbongo*	0.0
?	*ndombi*	0.0
Crustacea		
crab	*kala*	2.9
shrimp	*kanji*	1.6
Mollusc		
African snail	*mbembe*	11.7
Honey		
African bee	*foki*	21.3
stingless bee	*dandu*	3.5
stingless bee	*moko*	1.5
Plant seeds		
Panda oleosa Pierre	*kanna*	9.7
Irvingia wombulu Vermoesen	*mobolu*	0.0
Klainedoxa gabonensis Pierre ex Engl.	*bokoko*	0.0
Plant leaves		
Gnetum spp.	*koko*	0.8
Dewevrea bilabiata Micheli	*kata*	0.1
fern	*manjumbu*	1.8
?	*mabodo*	0.1
Fungi		
?	*tulu-sakusa*	0.2
?	*mawoluolu*	0.2
?	*tokpoli*	0.0
?	*deddele*	0.4
?	*moleseko*	0.4

Table 3. Dietary energy and protein intake

Food type	4/14–27/'10 (20 persons)					8/16–9/5/'03 (16 persons)					10/2–22/'05 (23 persons)					Energy per 100 g	Protein per 100 g	Edible ratio
	1)Food intake	2)Energy intake		Protein intake		Food intake	Energy intake		Protein intake		Food intake	Energy intake		Protein intake				
	kg	kcal	%3)	g	%3)	kg	kcal	%3)	g	%3)	kg	kcal	%3)	g	%3)	kcal	g	
Yam tubers	379.6	1565.4–1733.1	84.2	21.0–44.7	61.9	427.8	1618.9–1792.3	63.2	21.7–46.3	26.1	650.1	1712.8–1896.3	68.7	22.9–48.9	32.9	112–124	1.5–3.2	0.7
Nuts	6.8	124.9	4.5	3.8	7.2	16.4	275.6	10.2	8.5	6.5	26.9	315.2	12.0	9.7	8.9	498	15.3	0.9
Fungi	1.1	1.3	0.0	0.1	0.2	2.7	2.9	0.1	0.1	0.1	6.9	5.2	0.2	0.2	0.2	32	1.5	0.9
Games' meat	1.9	7.6–10.0	0.3	1.9–3.1	4.7	119.4	427.2–560.4	18.3	65.8–74.5	53.8	136.4	339.7–445.6	14.9	52.3–59.2	51.1	109–143	16.8–19.0	0.68
Reptile	5.4	18.7	0.7	2.9	5.5	2.5	8.0	0.3	1.2	0.9	0.0	0.0	0.0	0.0	0.0	94	14.4	0.7
Bird											0.1	0.2	0.0	0.1	0.1	105	22.5	0.5
Bird egg						0.3	1.2	0.0	0.1	0.1						140	11.8	0.85
Fish	8.9	27.9–41.9	1.2	5.3–5.9	10.6	20.6	59.3–89.3	2.8	11.3–12.6	9.2	7.7	15.5–23.3	0.7	2.9–3.3	2.8	85–128	16.2–18.1	0.6
Crutaceae	3.1	7.2	0.3	1.6	3.0	0.2	0.2	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	63	13.9	0.3
Snail	4.7	18.4	0.7	3.1	5.8	0.3	1.2	0.0	0.2	0.2	0.7	1.7	0.1	0.3	0.3	107	17.7	0.4
Termite	0.0	0.0	0.0	0.0	0.0	5.9	71.0	2.6	4.1	3.1	8.6	72.0	2.7	4.1	3.8	356	20.4	1
Honey	19.8	226.3	8.1	0.3	0.6	6.0	63.0	2.3	0.1	0.1	2.3	17.0	0.6	0.0	0.0	311	0.4	0.75
Leaves	2.7	2.5	0.1	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25	3.0	0.9
Friut						?	?	?	?	?								
Total	434.0	2000.2–2184.3	100.1	40.3–65.8	100.1	602.1	2528.5–2865.1	99.9	113.1–142.8	100.1	839.8	2479.4–2776.6	99.9	92.5–125.8	100.1			

1) Estimated food intake: It was got, if discarded and remaining food was subtracted from food brought into the camp.
2) Estimated energy intake per consumption-day.
3) We calculated the percent using the intermediate value as for yam tubers, game's meat, fish and total.
Consumption-day: Number of participants × research days; 296 in Aug. '03, 425.1 in Oct. '05, and 271.6 in Apr. '10.
Conversion factors: boy and girl 10 or over and adult = 1, and boy and girl under 10 = 0.7.
?: The amount of fruit eaten was not weighed.

Table 4. The fresh weight of edible tubers brought into the camp during the research period

	Study season											
	Our study									Yasuoka's study		
	Apr. '10 (CD = 271.6)			Aug.–Sep. '03 (CD = 296)			Oct. '05 (CD = 425.1)			Feb.–Apr. (CD = 3325)		
Tubers of yam and yam-like plants	Weight kg	%	W/CD	Weight kg	%	W/CD	Weight kg	%	W/CD	Weight kg	%	W/CD
Dioscorea praehensilis	525.1	91.1	1.93	636.6	96.4	2.15	1030.6	94.3	2.42	4519.8	83.0	1.36
D. semperflorens	2.3	0.4	0.01	10.9	1.6	0.04	27.0	2.5	0.06	654.6	12.0	0.20
D. mangenotiana	31.0	5.4	0.11	7.7	1.2	0.03	22.4	2.0	0.05	61.8	1.1	0.02
D. burkilliana	16.5	2.9	0.06	4.8	0.7	0.02	12.3	1.1	0.03	184.7	3.4	0.06
D. minutiflora	0.8	0.1	0.00	0.7	0.1	0.00	0.6	0.1	0.00	22.7	0.4	0.01
Dioscoreophyllum cumminsii	0.7	0.1	0.00							3.1	0.1	0.00
Total	576.4	100.0	2.12	660.7	100.0	2.23	1092.9	100.0	2.57	5446.7	100.0	1.65

CD (consumption-day): Adjusted number of participants × research days.
W/CD: Weight per consumption-day.
Consumption-day in this study: adults and boys and girls over 10 = 1, boys and girls less than 10 = 0.7.
Consumption-day in Yasuoka's study: adult = 1, 12 ≤ boys and girls = 1, 2 < boys and girls < 12 = 0.5, babies ≤ 2 = 0.

these 3 food types more than 90 percent. Yam tubers in this survey occupied 84.2 percent of the daily total energy intake and other food types only 15.8 percent. The supply of game meat in this survey was negligibly small. The supply of nuts was less than one-half of those in the previous 2 surveys although it kept the third ranking in the contribution to total energy intake. The daily total protein intake was estimated at 39.6–63.9 g per consumption-day in this survey. This value was also very low relative to those in both the survey of 2003 and the survey of 2005 because the game meat, which supplied the dietary protein of 50–70 g per consumption-day in both previous surveys, was largely absent. Other animal food also contributed less to the dietary protein supply than in the previous surveys although more reptiles and snails was caught in this survey, and fish more than in the rainy season of 2005.

Among the 5 species of wild yam tubers collected, the amount of *D. praehensilis* was overwhelmingly the largest (as it was in the previous 2 surveys). The amounts of biennial species *Dioscorea mangenotiana* and perennial species *Dioscorea burkilliana* in this survey were slightly larger than in the previous surveys (Table 4).

The cooperators usually collected wild yam tubers in married couple units. Each couple left the camp with the intention to collect wild yam tubers on an average of 4.5 days a week. This frequency was slightly more than those of the previous surveys, an average of 3.5 days a week. In the previous 2 surveys we could see no sign of resource shortage during the survey period: There was no statistically significant difference in the weight of yam tubers collected by couple between the first half and the last half of the survey period. In this survey, however, the yam resources possibly decreased during the survey period: The weight of yam tubers collected by family in the last half of the survey period was smaller than that in the first half although there was no statistically significant difference ($P = 0.0547$) (Table 5). As for the daily energy intake we could also observe the same thing (Table 6); the daily energy intake of 6 among 8 families decreased from the first half of the survey period to the last half.

Table 5. Weight variation of wild yam tubers collected between the first half and the last half of survey period

Apr. ’10	First	Last
Couple no.	kg/day	kg/day
SRF1	6.8	4.2
SRF2	6.9	7.5
SRF3	4.1	2.9
SRF4	4.5	5.6
SRF5	7.0	2.3
SRF6	6.4	4.5
SRF7	3.3	2.5
SRF8	9.1	4.8
Median	6.6	4.4
Wilcoxon’s test	0.0547	

Yam tubers include the tubers of *Dioscoreophyllum cumminsii.*

Table 6. Variation of estimated dietary energy intake between the first half and the last half of survey period

Apr. ’10	First	Last
Family no.	kcal/day	kcal/day
SRF1	5966	3691
SRF2	8518	8752
SRF3	4435	3436
SRF4	3943	5229
SRF5	6363	2964
SRF6	6027	4513
SRF7	6550	3051
SRF8	8191	4822
Median	6195	4102
Wilcoxon’s test	0.0547	

Table 7. Comparison of work time and steps walked between the first half and the last half of research period

Apr. '10	Sex	Work time per day (min.)			St	Steps walked per day			St
		Entire	First half	Last half		Entire	First half	Last half	
		Mean±SD	Mean±SD	Mean±SD		Mean±SD	Mean±SD	Mean±SD	
SRF11	M	466.8±73.7	478.4±78.7	455.1±72.6	ns	5931±2521	5533±1238	6330±3445	ns
SRF21	M	440.5±97.4	483.6±85.5	397.4±94.3	ns	10737±2458	10902±2570	10571±2535	ns
SRF31	M	470.4±93.7	513.6±85.4	427.3±85.9	ns	3729±1843	3559±1187	3899±2426	ns
SRF41	M	437.3±89.2	494.6±48.5	380.0±85.0	**	4536±1701	4136±1375	4935±2001	ns
SRF51	M	486.7±94.3	507.6±64.5	465.9±118.7	ns	8363±2111	7258±756	9468±2497	*
SRF61	M	476.9±70.3	507.3±42.2	446.6±82.3	ns	9165±2080	7744±1235	10586±1771	**
SRF71	M	470.4±93.7	513.6±85.4	427.3±85.9	ns	13693±3176	14687±3163	12699±3090	ns
SRF81	M	455.6±73.7	481.0±64.8	430.3±77.9	ns	8194±2014	8276±1783	8111±2366	ns
SRF12	F	458.9±91.6	478.1±78.3	439.7±105.8	ns	5589±2230	5570±996	5608±3128	ns
SRF22	F	439.1±99.7	484.7±83.7	393.4±98.3	ns	9399±3296	9330±2501	9468±4155	ns
SRF32	F	481.6±89.6	525.0±70.2	438.3±89.8	ns	6953±2873	6292±1388	7613±3866	ns
SRF42	F	428.6±104.7	491.0±51.4	366.3±109.7	*	5204±2365	3995±1189	6414±2700	0.051
SRF52	F	480.9±110.8	507.0±64.5	454.7±144.3	ns	6729±2366	5802±1079	7656±2993	ns
SRF62	F	481.9±62.6	506.7±41.9	457.0±72.7	ns	7461±3056	6368±1086	8915±3908	ns
SRF72	F	481.6±89.6	525.0±70.2	438.3±89.8	ns	10980±2650	11624±1328	10337±3533	ns
SRF82	F	458.9±71.0	487.0±54.8	430.9±78.0	ns	13099±1507	13106±133	13093±1907	ns

St: Student's t-test, * $P<0.05$, ** $P<0.01$.

Table 8. Daily fructuation of the weight of yam tubers collected, the working time and the number of steps walked on the yam collecting day by couple (Apr. '10)

Couple no.	Order of the yam collecting day												
Yam weight (kg)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	Sp	Ss
SRF1	14.4	13.7	8.7	10.0	9.7	11.7	10.7	5.9	-	-	-	-0.476	ns
SRF2	15.4	7.3	20.1	5.0	3.3	8.7	1.9	16.9	9.2	22.3	-	0.200	ns
SRF3	4.0	6.7	5.2	2.5	4.3	8.9	20.2	7.9	10.9	-	-	0.717	$P<0.05$
SRF4	12.9	8	11.8	1.5	7.1	3.5	11.2	3.1	4.9	4.6	8.1	-0.336	ns
SRF5	7.2	4.2	2.4	4.2	12.8	2.6	1.7	0.2	-	-	-	-0.647	ns
SRF6	18.7	6.2	13.3	1.7	9.4	1.2	6.2	2.1	6.6	-	-	-0.367	ns
SRF7	7.5	8.2	7.9	4.9	10.8	3.7	5.6	-	-	-	-	-0.393	ns
SRF8	12.3	17.3	8.0	5.0	10.1	11.2	9.1	14.0	8.9	-	-	-0.167	ns
Time (min.)													
SRF1	870	1138	714	1066	1124	1000	1028	1070	-	-	-	0.191	ns
SRF2	907	955	806	939	1211	836	703	885	1130	512	-	-0.297	ns
SRF3	920	865	957	991	1058	1163	707	960	741	-	-	-0.083	ns
SRF4	944	943	910	1139	1071	1065	1039	951	958	1028	628	-0.009	ns
SRF5	1066	860	1198	999	1038	718	940	1125	-	-	-	-0.095	ns
SRF6	1073	987	1006	1150	1176	1043	1040	1030	1166	-	-	0.267	ns
SRF7	959	1046	1196	941	1044	731	1039	-	-	-	-	-0.321	ns
SRF8	934	958	987	1007	766	1171	1048	1074	727	-	-	0.183	ns
Steps													
SRF1	7600	12856	11272	12209	11193	8411	17243	11035	-	-	-	0.095	ns
SRF2	17862	16682	15444	24353	22286	18921	15172	25011	16548	13589	-	-0.236	ns
SRF3	6059	7458	10584	9287	6296	10354	11838	8901	11195	-	-	0.600	ns
SRF4	12992	13144	18022	14939	13934	13958	19331	14146	17905	17311	13731	0.327	ns
SRF5	25422	18081	26578	26547	28174	17695	29299	19158	-	-	-	0.119	ns
SRF6	14052	13339	12603	13320	14967	18493	18366	20973	15227	-	-	0.733	$P<0.05$
SRF7	8594	7790	11072	11742	12635	7178	11860	-	-	-	-	0.357	ns
SRF8	24206	18996	19646	22258	18758	26064	25822	25035	18852	-	-	0.133	ns

Sp: Spearman's rank correlation coefficient between the order of the yam collecting day and the weight of yam tubers collected, the working time and the number of steps walked on the yam collecting day. Ss: Statistical significance.

Working Time and Steps Walked

We timed the periods the cooperators spent outside the campsite, except for urination and carrying water and fuel for their fires. This time (working time) could be regarded as the time spent in the cooperators' food-getting activities. We also recorded with pedometers the number of steps walked by cooperators every day. Although the pedometer cannot monitor physical actions such as digging for tubers or cracking nutshells in a sitting position, it measures the walking distance of cooperators and indicates their activity range. In Table 7, the working time and the number of steps walked of cooperators are shown. Each couple usually went out foraging together and also returned back together during the survey. Each couple left the campsite about 8 o'clock every morning and they spent 400–500 minutes in foraging activities before they returned between 14:00 to 17:00. Almost all cooperators slightly reduced their working time from the first half of survey period to the last half although there was no statistically significant difference except for 1 couple. The number of steps walked varied from 4,000 to 13,000 between individuals during the survey. Most cooperators did not change, or slightly increased, the number of steps walked from the first half of survey period to the last half. Focusing yam collecting activity, we could see a similar tendency. In Table 8, the weight of yam tubers dug out, the working time and steps walked of each couple in the yam collecting day, the day when the cooperators engaged intentionally in seeking and digging out yam tubers, are shown. The weight of tubers and the working time of most couples decreased slightly as the day went on although there was no statistically significant difference. On the other hand, most couples increased their steps walked as the day went on although there was no statistically significant difference.

Table 9. Comparison of cooperators' weight between the first half and the last half in 14 consective days

Ind. No. Apr. '10	Sex	Mean	FH	LH	t-test	Trend	Ind. No.	Sex	Mean	FH	LH	t-test	Trend
SRF11	M	33.0±0.33	33.0±0.44	33.0±0.22	ns		SRF12	F	35.6±0.34	35.8±0.31	35.3±0.21	*	-
SRF21	M	53.0±0.74	53.3±0.90	52.8±0.53	ns		SRF22	F	47.3±0.52	47.1±0.53	47.5±0.50	ns	
SRF31	M	43.3±0.69	43.3±0.95	43.3±0.36	ns		SRF32	F	43.1±0.91	43.5±1.00	42.6±0.60	ns	
SRF41	M	47.8±0.61	48.1±0.71	47.5±0.26	*	-	SRF42	F	47.6±0.48	47.8±0.61	47.4±0.25	ns	
SRF51	M	43.0±0.54	43.2±0.60	42.7±0.34	ns		SRF52	F	39.0±0.48	39.2±0.56	38.9±0.34	ns	
SRF61	M	46.6±0.54	46.9±0.43	46.3±0.49	*	-	SRF62	F	43.3±0.55	43.7±0.43	42.9±0.39	**	-
SRF71	M	59.9±0.40	60.0±0.43	59.8±0.38	ns		SRF72	F	40.7±0.48	41.1±0.20	40.3±0.35	***	-
SRF81	M	45.3±0.27	45.3±0.30	45.4±0.24	ns		SRF82	F	33.7±0.58	34.2±0.49	33.3±0.30	**	-

FH: mean weight during the first half of survey period.
LH: mean weight during the last half of survey period.
Trend: Plus indicates weight's increasing and minus weight's decreasing from the first half to the latter half of survey period.
* $P<0.05$, ** $P<0.01$, *** $P<0.001$.

Body Weight of Cooperators

In this survey the body weight of most cooperators varied little day to day. Comparing it between the first half and the last half of the survey period, however, 2 male cooperators and 4 female cooperators slightly lost weight in the last half whereas the rest of cooperators kept their weight consistently (Table 9). This is different from the data on the previous 2 trips, where almost all the cooperators kept their weight or modestly increased their weight in the last half. All the children maintained their weight during the trip.

DISCUSSION

General Overview of the Controlled Foraging Trip in a Communal Forest

Since this controlled foraging trip was conducted under the usage restriction on wire snares in the communal forest where there was the possibility of hunting and gathering pressure on food resources, we shortened the survey period from 20 days as in the previous 2 surveys to 14 days. This 14-day trip was completed as planned although it had some issues that need further examination. Firstly, 6 among 16 cooperators decreased their body weight, although slightly, from the first half to the last half of survey period. Secondly, the dietary energy intake of cooperators was 2000–2180 kcal per consumption-day, which was 480–680 kcal per consumption-day smaller than in the previous surveys. The dietary energy intake by family also decreased slightly from the first half to the last half of the survey period. Thirdly, the weight of collected yam tubers, which supplied the bulk of total dietary energy intake, reduced a little in the last half of survey period. These issues may have arisen partly due to the abovementioned severe survey conditions. However, there was no evidence that the cost of food getting activities increased from the first half to the last half of the survey period. The working time did not change between the first half and the last half of the survey period. Although a few cooperators increased slightly the steps walked in the last half of the survey period, most cooperators did not demonstrate any remarkable change in the number of steps walked. At the beginning of the last half of survey period some cooperators seemed to be bored with the foraging trip so we made a proposal to the cooperators to halt the trip after the 10th day. However, they desired to complete the trip. The boredom was probably caused by the paucity of game caught during this survey period. In previous surveys, most cooperators squealed for joy when big game were brought back to the camp, as game meat was a pleasure food for the cooperators. But on this trip they had no chance to obtain big game meat without their usual wire snares. Given such conditions, it would have been difficult to stay with the survey for the same 20-day period of the previous surveys, so the period of 14 days was probably sufficient for its purpose.

Productivity of *D. praehensilis* in a Communal Forest

Yam tubers, which supplied over 80 percent of the total dietary energy, were of most importance in this survey as well as in the previous two surveys. The daily amount of yam tubers brought back to the camp was equivalent to that in the survey of 2003, or somewhat smaller than that in the survey of 2005. Among 6 species of yam and yam-like plants collected, the annual *D. praehensilis* occupied over 90 percent, by weight, of all yam tubers as it did in the previous 2 surveys. Although the weight of *D. praehensilis* tubers had a tendency to decrease slightly as the days went on, they could support the 14-day foraging trip of 20 persons in a communal forest. At least as far as yam tubers were concerned, we could not find evidence that human beings could not sustain their foraging lifestyle in an African tropical rainforest. In the previous surveys the cooperators located the campsite on the border of the present National Park, 2 days on foot from the Ndongo Village, because they had known the forest around the campsite to be rich in game animals and to have large clumps of *D. praehensilis* available (Sato et. al., 2006). Both previous surveys successfully ended with no sign of resource depletion. In this survey, the cooperators located the campsite in an accessible communal forest about 2 hours on foot from the cooperators' settlement. Although they chose a place suitable for foraging activities, the forest around the campsite was routinely entered by other Baka people who set wire snares or collected other food resources or life resources. It was therefore likely that this forest was under continual hunting and gathering pressure. Even so, the cooperators of 8 couples completed the 14-day foraging trip although the food procured was not as affluent as in the previous 2 surveys. The completion of this trip is firstly attributable to the abundance of *D. praehensilis* tubers. Although we have no idea of the biomass of *D. praehensilis* tubers in communal forests, the amount of these tubers harvested during this survey suggests the potential of southeastern Cameroon forest as a foragers' habitat.

Recently Yasuoka (2013) reported a notable observation. Returning to the campsites of the past hunting and gathering trips (in 2002 and 2005) of his Baka group, inhabiting the Zoulabot Ancien Village about 100 km to the northwest of the Ndongo Village, Yasuoka found numerous stems of *D. praehensilis* around the abandoned campsites. According to the Baka people who had participated in the hunting and gathering trips, these stems germinated not from planted tubers but from discarded tubers. This observation demonstrates that human beings are also dispersers of *D. praehensilis* and their usage of *D. praehensilis* is likely to increase its productivity in the forests. Moreover as Dounias (1993) pointed out, after the Baka people dug out *D. praehensilis* tubers, they routinely left a part of the tuber for the next germination. Dounias (1993) called this behavior paracultivation. Therefore, with regards to *D. praehensilis* we must not overstate the human impact on resource depletion in communal forests.

Seasonality of *D. praehensilis*

This survey was conducted in April, the minor rainy season, which was considered to be the most unsuitable for harvesting the tubers of *D. praehensilis* (Dounias, 2001; Yasuoka, 2006). Discussing the seasonality in full elsewhere (Sato et al., 2012), we will summarize it here. The biological cycle of *D. praehensilis* is as follows: It renews its aerial stem and tuber reserves every year, uses its tuber as an energy source for the sprouting and growth of new stems from April to July, stores tuber reserves from August to November, and then keeps its tuber reserves at maximum for the next sprouting after March (Dounias, 2001). In short, according to Dounias (2001) and Yasuoka (2006), April, the beginning of the minor rainy season, and August, the beginning of the major rainy season, were not good seasons for harvesting *D. praehensilis* tubers but the major dry season from December to March was the best season. However, our observation of the controlled foraging trips did not coincide with their idea. The weight of *D. praehensilis* tubers in our April 2010 trip and in the previous 2 trips of August 2003 and October 2005 was the same or more than that of the hunting and gathering trip in the major dry season, which Yasuoka (2006) reported. We proposed the following hypothesis to resolve this dissonance (Sato et al., 2012); there could be another variety of *D. praehensilis* that had a different starting point of the biological cycle. As shown in Figure 2, in this area there are 4 seasons: 2 rainy seasons and 2 dry seasons. The biological cycle mentioned above by Dounias had its starting point of renewing stems in the minor rainy season April to May and had the period for maximizing tuber reserves in the major dry season March. In our hypothesis, another variety of *D. praehensilis* could have its starting point in the major rainy season September to October and the period for maximizing tuber reserves in the minor dry season August. If this is correct, the tubers of *D. praehensilis* could be harvested almost all year round. The presence or absence of its seasonality, which would have a significant impact on a foraging lifestyle in the African tropical rainforest, should be examined.

GAME MEAT AS ESSENTIAL FOOD IN THE CONTROLLED FORAGING TRIP

In both previous 2 surveys, game meat obtained with wire snares was the second ranked food after yam tubers in dietary energy supply whereas in this survey few game animals were procured. The obvious reason was the restriction on wire snare usage in this survey. When we made the proposal to restrict the use of wire snares to the cooperators, they agreed and said that they had spears and could use woody vines for snaring instead wire. Cameroon domestic law forbids wire snaring but allows snaring using natural resources such as woody vines. In fact, however, the cooperators set no snares during the survey period; woody vines were probably much less effective. All male cooperators had spears and carried them whenever they left the camp. A small crocodile was killed with a spear during the survey period. Spears as a hunting weapon were not ineffective but the other Baka group killed many medium-sized duikers and bush pigs with spears during the long-term hunting and gathering trips (Yasuoka, 2006). In the communal forest where the density of game animals might be low such catches could not be expected. Finally, other game animals procured during the survey period included only 2 baby blue duikers: 1 caught by the dog and 1 retrieved from the stomach of a big snake. The observation of this trip suggests that few game animals are obtainable without wire snares in a communal forest. In the previous 2 surveys, the game meat supplied 340–560 kcal (15–19%) of daily energy intake whereas in this survey there was little dietary energy supplied by game meat, nor any alternative energy source comparable to it. The total dietary energy intake in this survey was 480–680 kcal smaller than that in the previous 2 surveys. The bulk of this shortfall was comparable to the dietary energy from game meat. The scarcity of game meat also led to a shortage of animal protein. The daily protein intake in the previous 2 surveys was estimated at 93.0–146.1 g, half of which was derived from game meat, whereas that in this survey was 39.3–63.6 g, only a small percent of which game meat supplied. This was a low level of protein intake (FAO, 2004). Game animals seem to be a critical food not only nutritionally but also psychologically for the Baka cooperators leading a foraging life. As mentioned already, in the previous 2 surveys the cooperators often squealed for joy and became happy when big game such as medium-sized duikers were brought back to the camp whereas in this survey we never saw such a happy scene but instead saw them look bored in the last half of the survey period. As far as the 3 controlled foraging trips are concerned, animal food other than game animals could supplied at most 6 percent of dietary energy. In short, there is no substitute animal food for game meat as a dietary energy and protein source. As observed in this survey, if there was little game meat, the total energy and protein intake was significantly reduced. Remaining in the situation with such a scarcity of game animals, the cooperators could not sustain the long-term foraging life. Game animals, like yam tubers, may be considered an essential food for a foraging lifestyle in the African tropical rainforest.

FOOD COMPOSITION OF THE FORAGING LIFESTYLE IN THE AFRICAN TROPICAL FORESTS

The top three food types in the ranking of dietary energy supply were yam tubers, game meat and nuts in the previous two surveys. These three types contributed over 90 percent of their total dietary energy. The food composition was similar also in long term hunting and gathering trips observed by Yasuoka of another Baka group (Yasuoka, 2006). Therefore in various seasons and different forest areas, a common food composition was observed. This suggests that the first rank: yam tubers, the second rank: game animals, and the third rank: nuts, which occupied in all about 90 percent in the dietary energy supply, were likely to be the common food composition of a foraging lifestyle in the southeastern Cameroon forest. In this survey, however, the food composition was different from those of the previous surveys; the first ranked, second ranked, and third ranked in the dietary energy composition were yam tubers, honey, and nuts, respectively. Although this didn't correspond to the above-mentioned previously established food composition due to the restriction of use of wire snares, this survey uncovered an interesting anomaly. Even so, the rank of yam tubers and nuts in this survey was the same as in the previous surveys.

However, other various foods that provided the remaining 5–10 percent of the total dietary energy had a not negligible role in sustaining a foraging lifestyle in African tropical rainforests. Supplying 226 kcal, about 8 percent of dietary energy intake in this survey, honey placed second next to yam tubers in the ranking of dietary energy source. Honey, like game animals, brought pleasure to the Baka people. As in the Ituri Forest of eastern Democratic Republic of the Congo, honey was a leading dietary energy source for Mbuti Pygmies from June to August (Ichikawa, 1981), honey is of importance to the African forest foragers. However, in the previous 2 surveys the dietary energy supply from honey was only a few percent of the total. In short, honey is a seasonal food, although of importance, for forest foragers. Fish is also a seasonal food. The dam and bail fishing by women in the dry season could obtain, although not much, secure catch in a short time. When no game meat was procured, fish was a welcomed addition to the foragers' meal as observed in this survey. However the high water level in the major rainy season makes it difficult to do the dam and bail fishing. Although reptiles, snails and termites also contributed only slightly to food supply and could not have been obtained anytime and anywhere, these animal foods had a similar role to fish as food. Various fungi and leaves also were included in meals almost every day. In this survey where little game meat could be promised, these diverse foods were especially of value to the cooperators. It is surprising that even the communal forest could have such a diversity of foods. In sunnary, yam tubers, game animals and nuts were found to supply the bulk of dietary energy and other various animal and botanical foods supply the remaining. It is likely that this is the basic food composition of a foraging lifestyle in the forests of southeastern Cameroon.

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